Europe is currently no superpower in computing, but it is never too late to try to become one.

The position of Europe in the world

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In order to set out a strategy for the future, it is important to know one's strengths and weaknesses, and it also helps to see opportunities, and to prepare for threats. Although Europe is currently no superpower in computing or in B2C ICT business, it is never too late to become one. For that to happen, it is important to understand the obstacles that make it difficult to grow global companies, and to develop a policy to remove them.

In this article, we present a SWOT (strengths, weaknesses, opportunities, threats) analysis of the European computing systems ecosystem. We make a distinction between three stakeholders: (i) publicly funded universities and research institutions ("Science and Technology"), (ii) the computing industry and its market, and (iii) the local and European governments responsible for creating an environment in which research, innovation and commercialization can take place ("Policy and Government"). Most data in this article comes from "Science, research and innovation performance of the EU 2020" [1].

We start with the strengths and weaknesses.

	Strengths	Weaknesses
Science and Technology	• High-quality education • Excellent research • World leader in lithography for semiconductor manufacturing	• Weak academia-industry link • Strong in research, but not in commercialization
Industry and Market	• Second largest market in the world • Stronger in systems than in components	• EU ICT contributes less to GDP than in other advanced countries • Lack of venture capital culture • Lack of advanced foundries
Policy and Government	• Common market • Decent public funding level of research	• Lack of ICT workers • Fragmentation of funding

Key insights

- Europe's global economic impact is dwindling because other regions are growing faster due to their demographics, rapid economic development, or abundance of natural resources. The biggest long-term challenge for Europe is to sustain economic growth with a shrinking active population and growing costs for social security. Maintaining the current standard of living will require a highly-educated and productive workforce.
- It is important for Europe to realize that computing is a key enabling technology of strategic importance because it is at the basis of all modern smart products and services. Europe should never lose the capacity to build its own computing solutions.
- Europe is a scientific powerhouse, but it fails to monetize some of its research results due to the lack of entrepreneurial talent, venture capital and a large enough ICT workforce.

Key recommendations

- The creation of well-funded international competence centres will help to retain and attract top talent, and to stay at the forefront of new digital technologies.
- Europe should continue to invest heavily in research and innovation, and in a more entrepreneurial Europe that generates lots of start-up, scale-up and global companies. Europe needs more venture capital to support the growth of scale-ups.
- Europe should invest in future-proof areas: the silver economy to support the ageing population (home automation, health, entertainment, …), technologies for sustainability (low power, recycling, …). Technologically, hardware accelerators, and artificial intelligence are key elements of future computing systems.

High-quality education

As mentioned in the article on "Europe should be the humans-first continent", Europe has an excellent and affordable educational system from preschool to university. According to the 2020 Times "Higher Education Ranking" [2], more than one third of the top 100 universities are located in Europe, including three in the top 10. The United States dominates the top 10 and the top 100, but all international rankings put Europe as the dominant continent in the top 500. This shows that Europe has a very solid higher education system.

Participation in higher education is growing in Europe, but it is still behind that of South Korea and the United States. Participation levels in China are catching up very quickly (Figure 1).

The growing participation unfortunately does not lead to more graduates; it is just enough to compensate for the shrinking population in the age band associated with higher education. A positive evolution is however that the share of science and technology graduates is the second highest in the world (after South Korea), and that Europe produces the second largest number of PhDs per population (Figure 2, again, after South Korea).

Given demographic evolutions, Europe will not be able to match the number of higher education graduates of China in the future. There are only three ways to increase the number of graduates.

- Try to further increase participation but there is not an unlimited number of students that are qualified to attend higher education (Europe sets 40% as a target; some countries already reach this level).
- Try to increase the number of graduates via lifelong learning. That means that workers are (re)trained while working, or between two jobs.
- A last option is to try to attract more foreign students/graduates, especially those who have plans to stay in Europe after graduation. Given the fact that almost every country in the world is trying to stop brain drain, and has created incentives to bring successful expats back to their home country, the impact of recruiting overseas students is also limited, and the numbers will always be lower than the number of local students.

In Europe, higher education is mostly government-funded, making it affordable for most young people. In Europe, the students pay on average less than 10% of the real costs of tuition fees while in the United States and the UK it can be up to 30%. European universities generally do not have access to the huge endowments of some US universities.

Excellent research

European universities produce significantly more PhD degrees per 1,000 of the population than American or Chinese universities. The majority of European countries perform better than the United States, even in science and technology.

During the last 20 years, Europe has maintained its global share of scientific publications, while the United States has seen a steady decline, and China has shown spectacular growth (Figure 3). Europe kept not only its share of scientific publications, but also its share of the 10% most highly cited publications. The US is also losing its share of highly cited publications. The same trend is visible for the top 1% highly cited publications. It is remarkable that the sum of highly cited publications from the United States and China has been almost

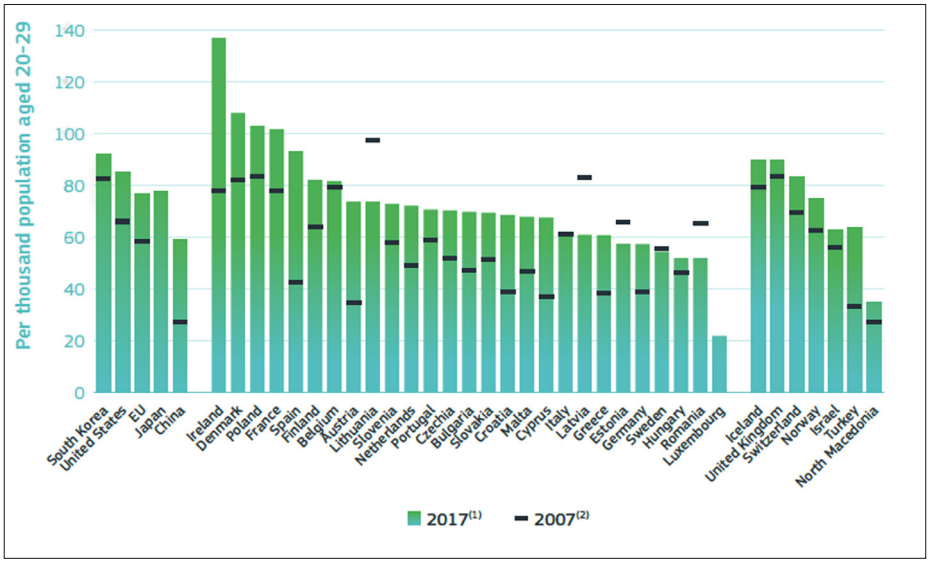

Figure 1: New graduates from tertiary education per 1000 population aged 20-29, 2007 and 2017 (Source: DG Research and Innovation)

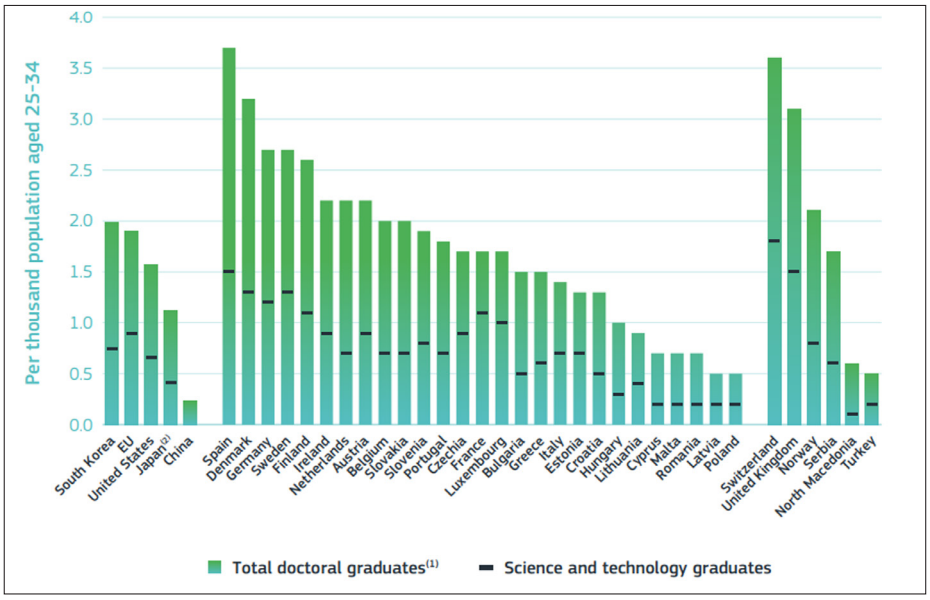

Figure 2: New doctoral graduates per 1000 population aged 25-34, 2017 (Source: DG Research and Innovation)

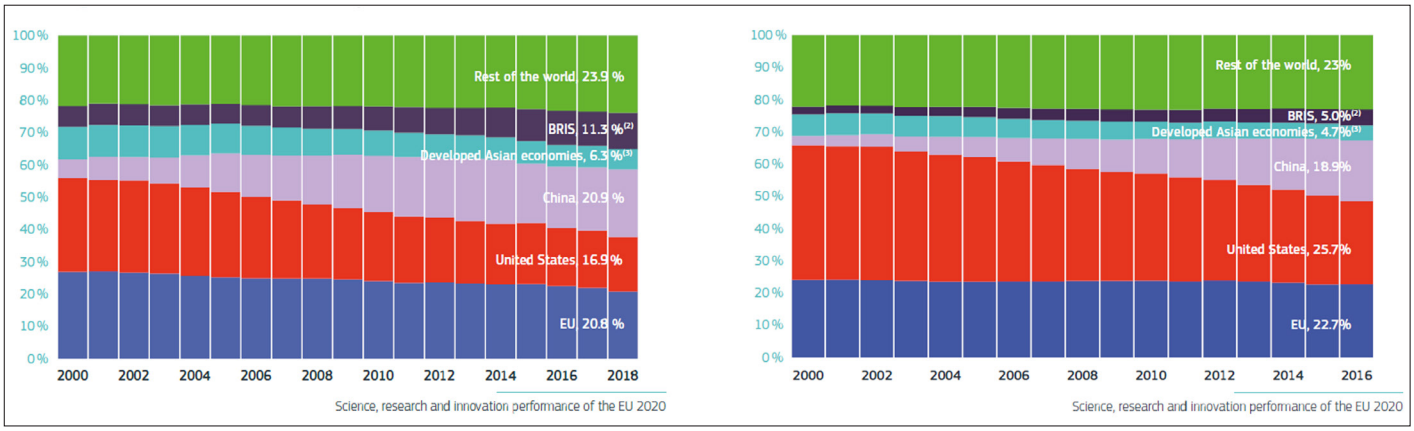

Figure 3: World share in scientific publications and 10% highly cited scientific publications (Source: DG Research and Innovation)

constant since 2000, which seems to indicate that the Chinese presence is growing at the expense of the US. Could there be a brain drain from the US to China: Chinese graduates from world-class American universities who return to China, and start a research career at home? If this trend continues, China will become the leader in publications and citations by the end of this decade. Hopefully, Europe will be able to defend its position in second place. As there is a correlation between the amount of public research funding and the number of highly cited publications, it seems crucial not to cut down on public research funding. The United States and Japan have been cutting public research funding in the last decade, and their numbers of publications and citations have followed the same path. Under the Trump administration, foreign students were discouraged to study

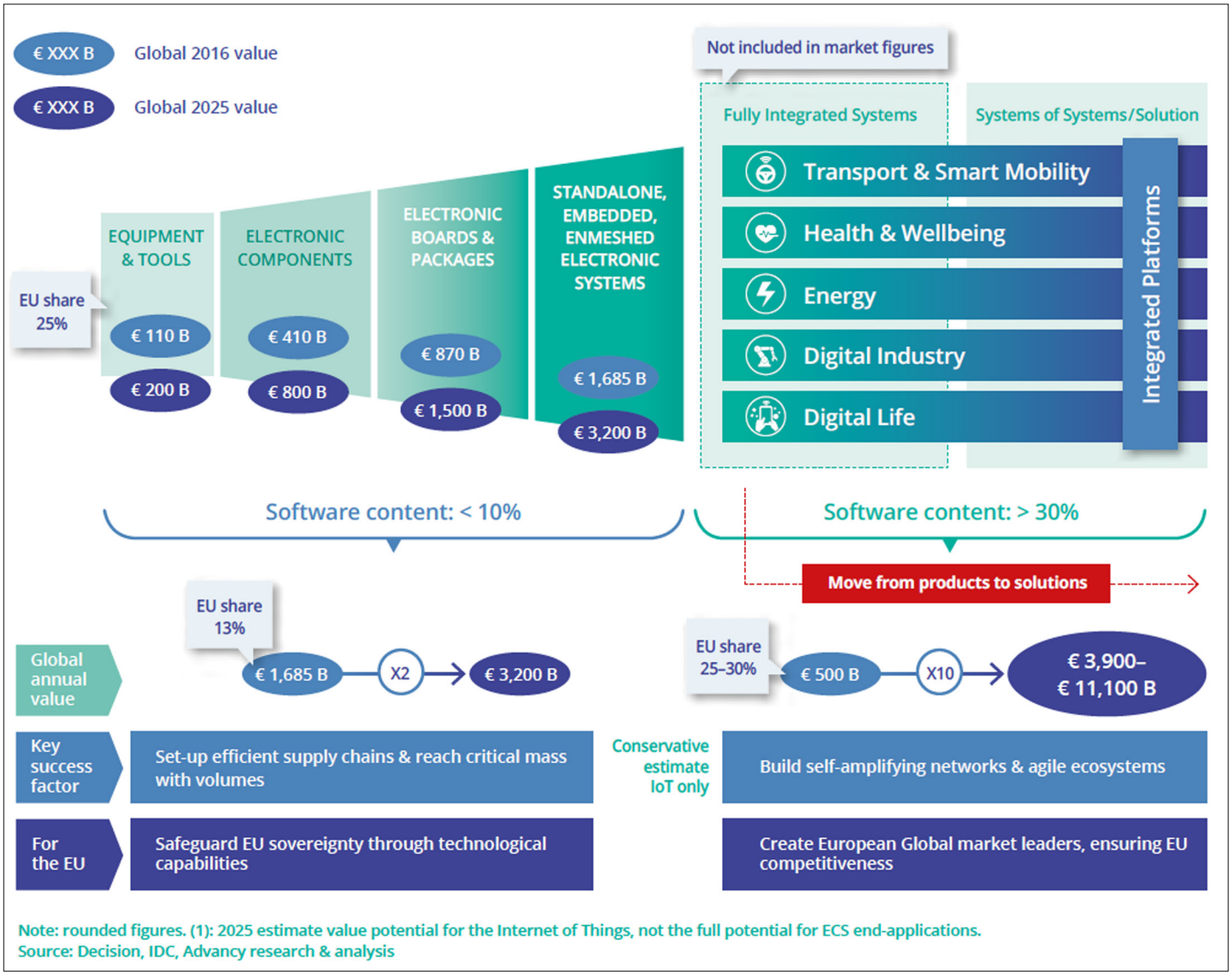

Figure 4: Embedded application domain markets (Source: ECS)

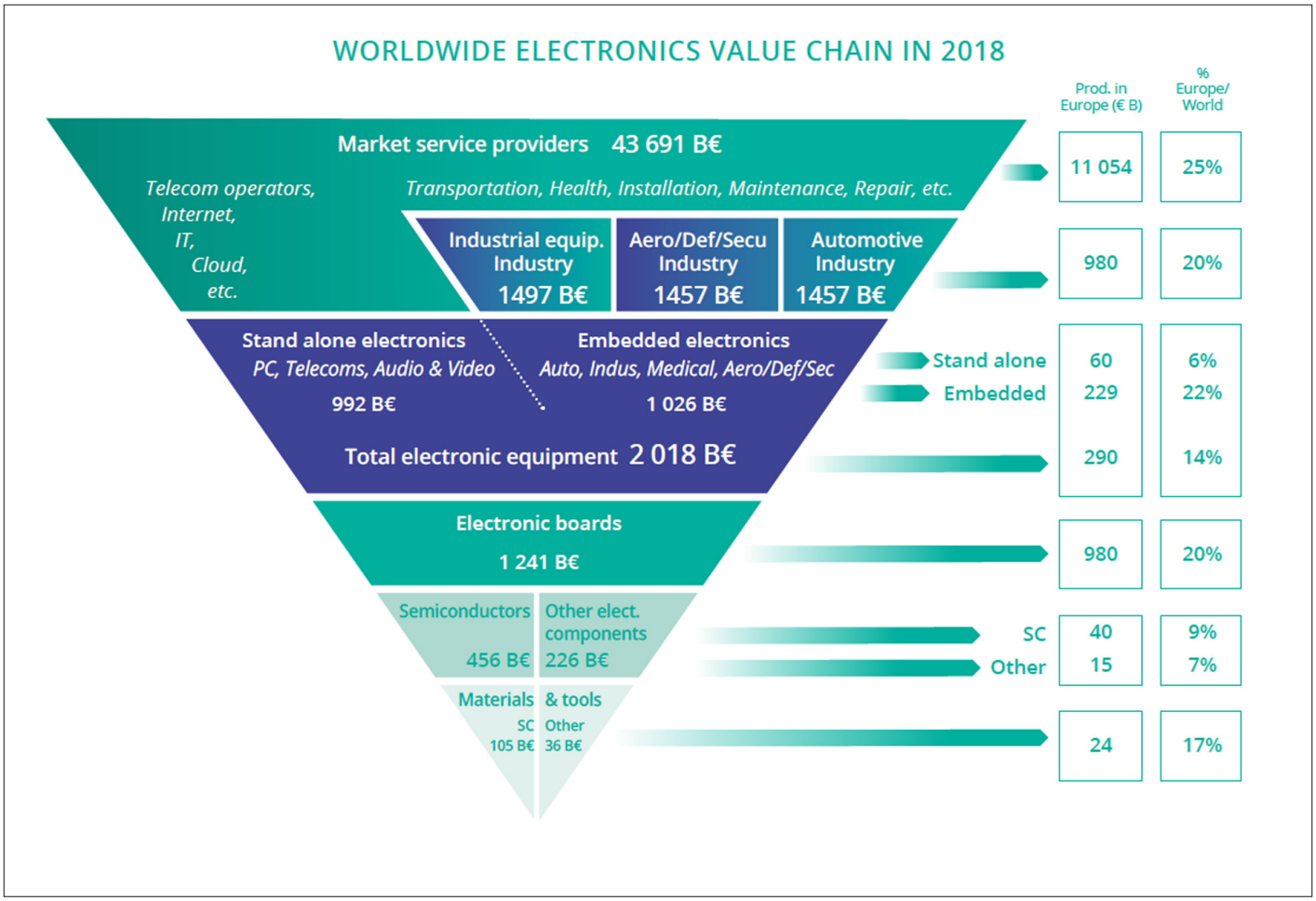

Figure 5: Worldwide electronics value chain in 2018 (Source: ECS)

in the United States, and currently the COVID-19 pandemic keeps them at home. Given the dependence of US research institutions on foreign talent, this might accelerate the decline in the number of publications, and citations.

World leader in lithography for semiconductor manufacturing

Europe has several research institutes and companies that are key players in semiconductor technology development (including ASML for making advanced EUV lithography machines, CEA, imec and Fraunhofer). They are Europe's biggest asset when it comes to the further development of CMOS-technology, and their expertise might be crucial to the development of post-CMOS technology.

Having the knowledge is also very important in order to understand the technology and therefore being able to use it efficiently in products. Curiously, since Global Foundries decided to step out of the race, Europe no longer has any advanced fabs. TSMC recently decided to build a fab in Arizona [10]. Europe might create incentives to attract advanced fabs too.

Second largest market in the world

According to the International Monetary Fund, Europe (EU-28) has the second largest GDP in the world, and the second highest GDP/capita.

Country	GDP in billion USD (2018)	GDP/capita USD (2018)
USA	20 513	62 571
EU	18 769	43 120
China	13 891	9 580

European businesses have access to a large internal market, with significant potential for growth in the new member states. Having access to a large internal market (like China and Europe) is an important advantage in times of troubled international trade relations. However, the European market is very fragmented due the diversity of regulations and languages across countries.

Stronger in systems than in components

In major embedded application domains, Europe is a global leader (Figure 5). According to the "Strategic Research Agenda for Electronic Components and Systems 2020" [3],Europe produces 25-30% of the global annual value at the system level, compared to 13% at the component level (Figure 4). The system level is expected to grow tenfold between 2016 and 2025 while the component level will only double. The system level is a clear strength in Europe, and a strength that we should exploit. The sector that is particularly strong is transportation (automotive, air, rail).

Common market

At the policy level, one of the strengths is the common market, and the fact that Europe can act as one economic block in

global trade negotiations. Individual countries do not have to negotiate individual agreements. However, there is still a long way to go before Europe becomes a fully integrated market with one set of laws, one currency and one tax system. The difference in minimum wages across Europe shows how pronounced the difference between countries is (Figure 6).

Strong public funding

Europe has a variety of research funding instruments, complementing national funding instruments. The research and innovation programmes of the European Commission help to stimulate research collaboration. European Research Council instruments support research excellence; the flagship programmes aim to create critical mass in key research areas; the European Institute of Technology aims to stimulate research and innovation; and joint undertakings like ECSEL aim to pool local and European funding to encourage research and innovation.

The total amount of public funding available makes Europe a good place to carry out R&D (at 0.7% of GDP). Worldwide, Europe is in second place after South Korea (Figure 7).

However, the relatively high amount of public funding across the EU does not compensate for the low R&D investments by industry (see weaknesses). When considered as a whole, Europe is dramatically lagging behind other parts of the world. The aim for Europe is to spend 3% of GDP on R&D, but it is still far away from that target (Figure 8).

The intensity of R&D translates into the number of researchers employed. Although Europe produces a higher number of PhD graduates per 1,000 of the population than any other continent, this does not lead to more employed researchers and almost half of them are employed by the public sector (Figure 9).

The total picture of R&D intensity is depicted in Figure 10. Asian countries appear to be preparing for the future. Their R&D intensity (apart from that of Japan) is growing as least as fast as the average growth in Europe.

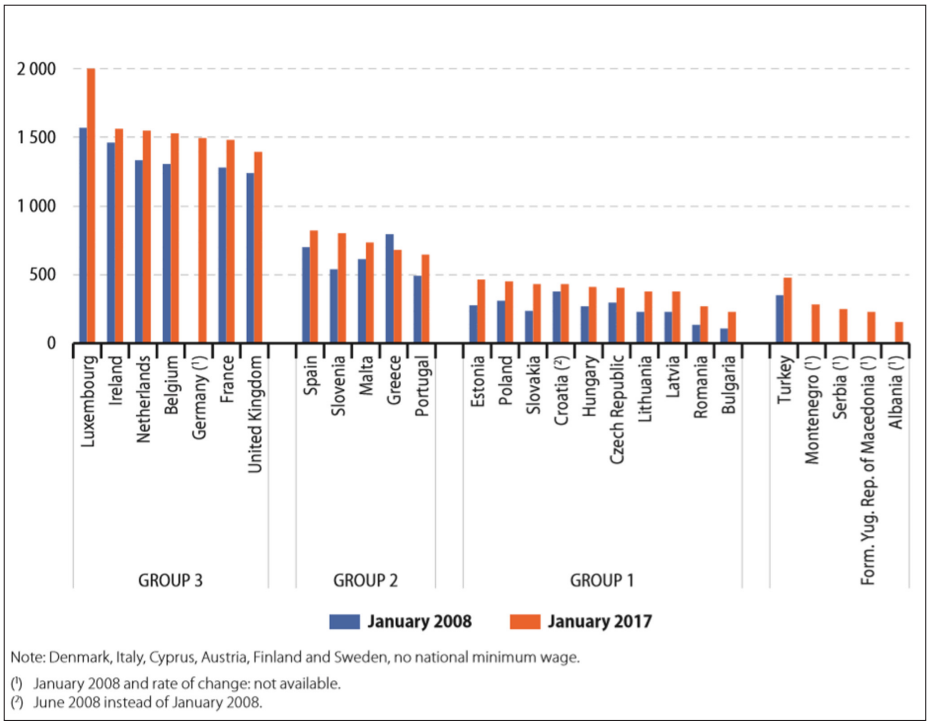

Figure 6: Minimum wages, January 2008 and 2017 (EUR per month) (Source: Eurostat)

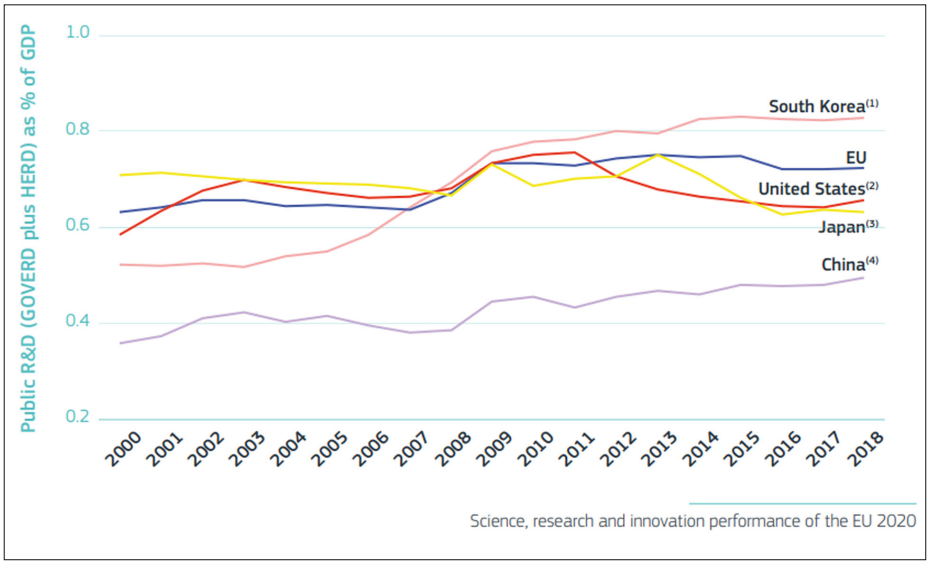

Figure 7: Evolution of public R&D intensity 2000-2018 (Source: DG Research and Innovation)

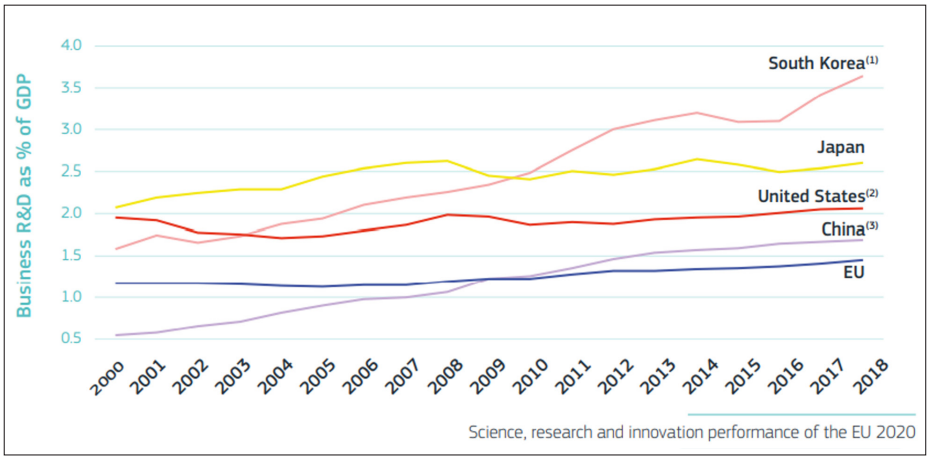

Figure 8: Evolution of business R&D intensity 2000-2018 (Source: DG Research and Innovation)

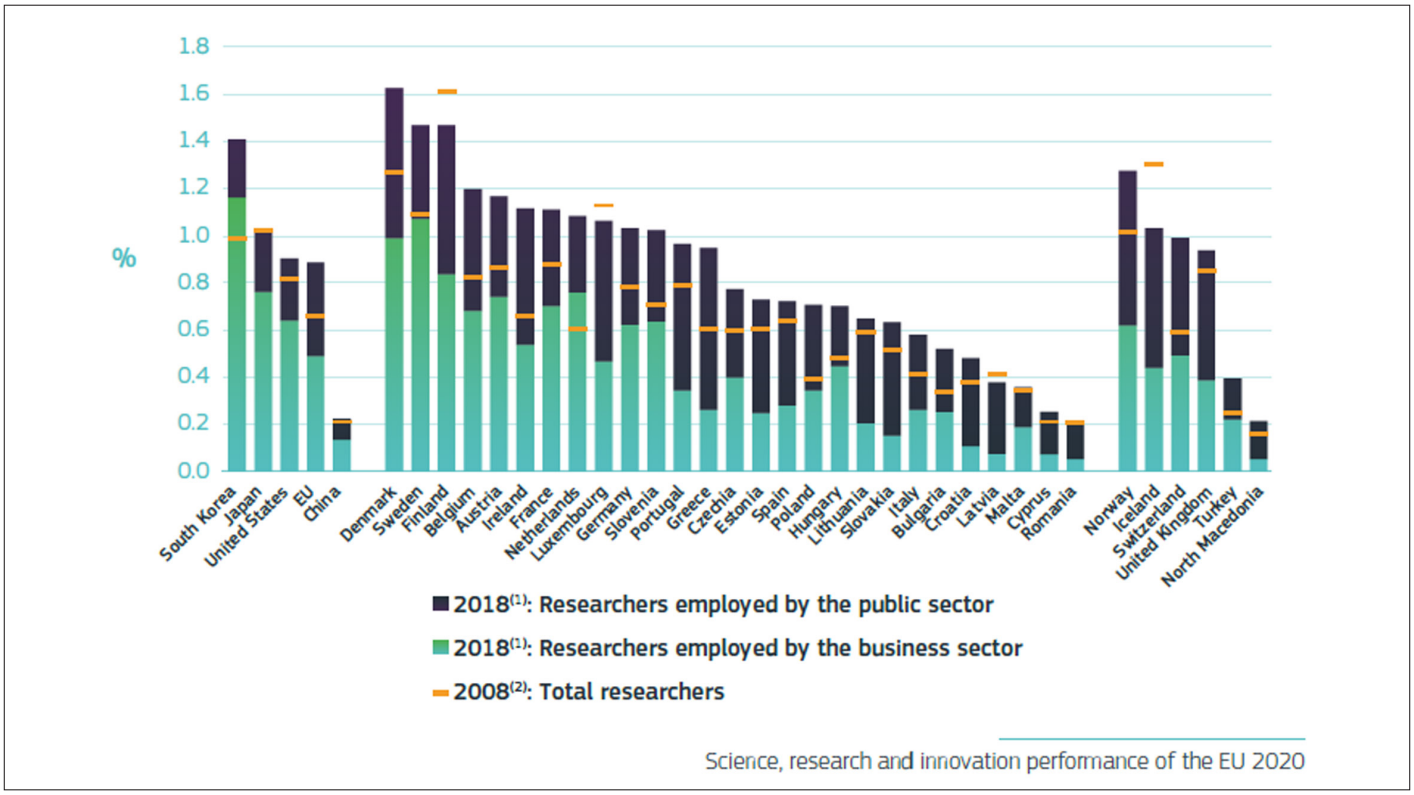

Figure 9: Total researchers (FTE) as % of total employment 2000-2018 (Source: DG Research and Innovation)

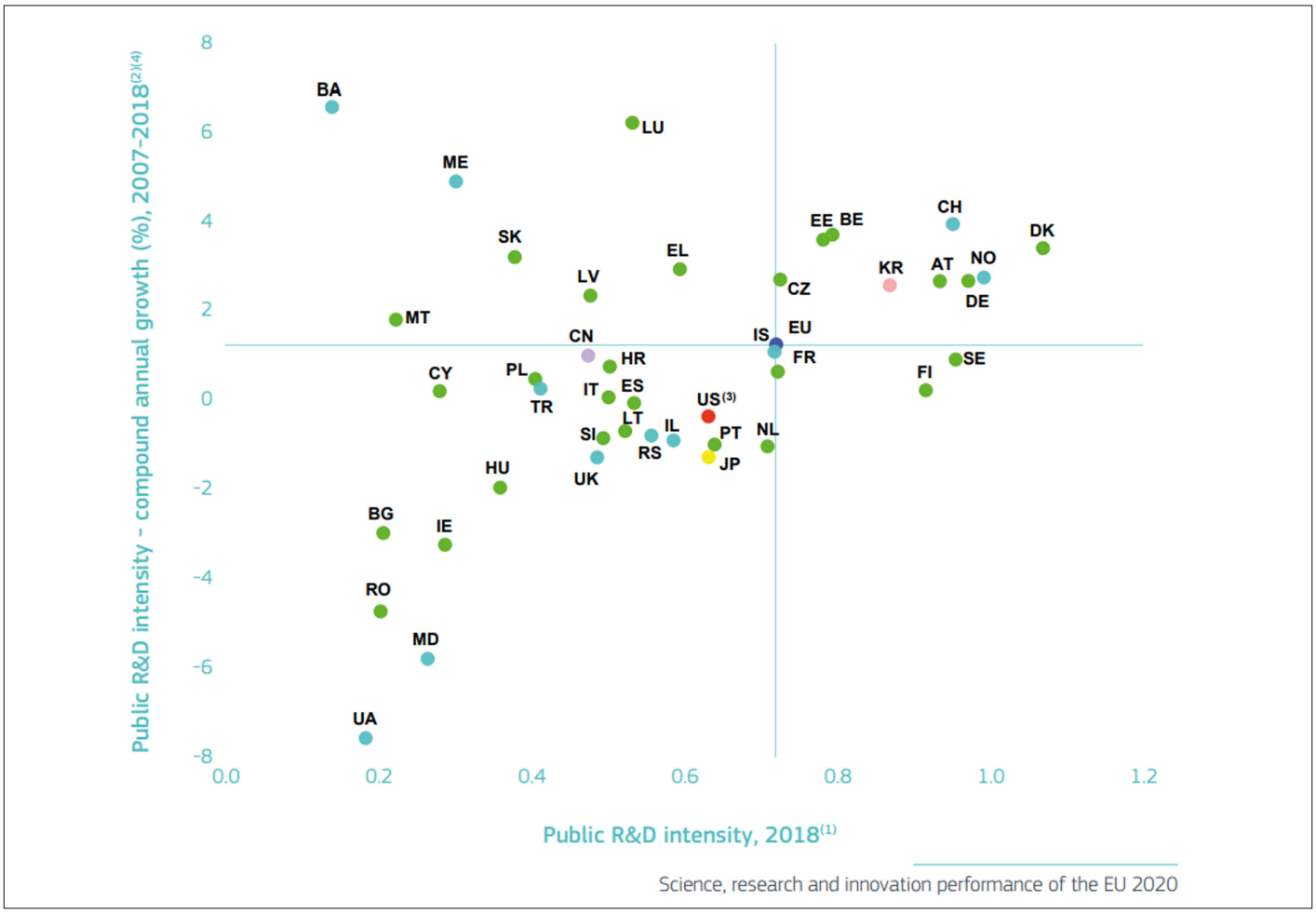

Figure 10: Public R&D intensity, 2018 and compound annual growht (%) 2007-2018 (Source: DG Research and Innovation)

Weaknesses

Weak academia-industry link

Compared to the United States, the collaboration between academia and industry (quantified as the number of joint scientific publications) is on average weaker, but there are large regional differences. The situation is fortunately improving (Figure 11).

Strong in research, but not in commercialization

Europe is lagging behind Japan with respect to the innovation output indicator (based on four components: patents, employment in knowledge-intensive activities, trade in knowledge-based goods and services, and the innovativeness of high-growth enterprises). There are however large differences in innovation performance between member states. The EU as a whole has recently caught up with the US (Figure 12).

In recent years, seven European cities have emerged as start-up ecosystems in the global top 30. Regional and European authorities are currently investing heavily in the creation and the support of start-up ecosystems in all European urban areas (Figure 13).

EU ICT contributes less to GDP than in other advanced countries

The European ICT-industry contributes around 4% to GDP (and is decreasing), compared to more than 5% in competing geographies [4] (Figure 14). One explanation is that Europe lacks GAFAM (Google, Apple, Facebook, Amazon, Microsoft) or BATX (Baidu, Alibaba, Tencent, Xiaomi), and other major ICT companies like HP, Dell and IBM, and the ecosystem supporting them. One exception is Ireland, which is home to the European headquarters of several major ICT companies. Figure 15 shows what a missed opportunity this is. The lack of such companies is a structural weakness which also limits the innovation potential for the ICT sector (the smaller the sector, the fewer the resources available to invest in research and development). The lack of such large corporations can be explained by the lack of venture capital (VC) culture in Europe. In order for companies to grow to be worth to US $ 50-100 million, they have to enter non-European capital

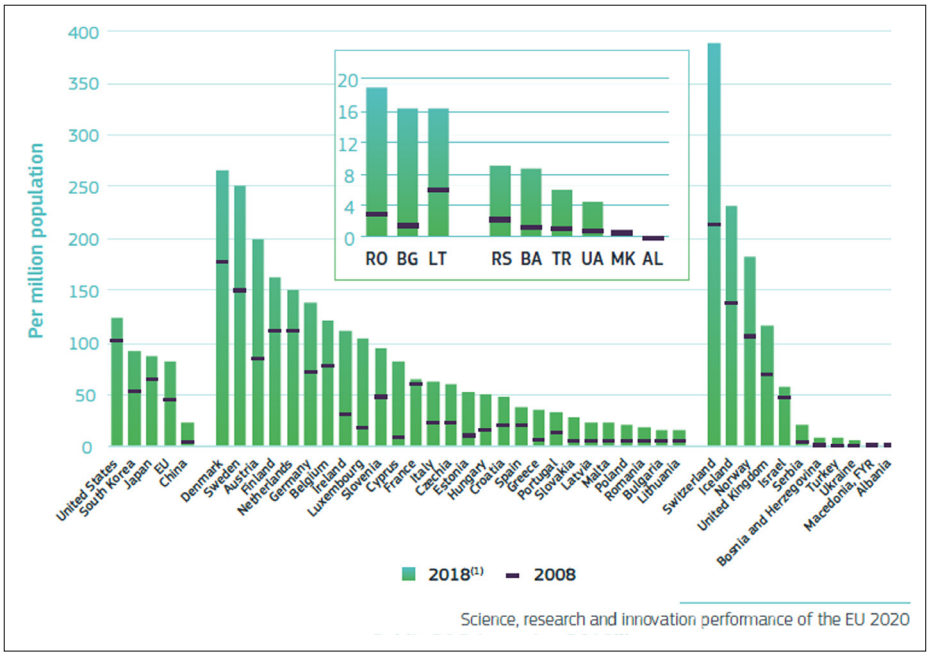

Figure 11: Public-private co-authored scientific publications per million population 2008 and 2018 (Source: DG Research and Innovation)

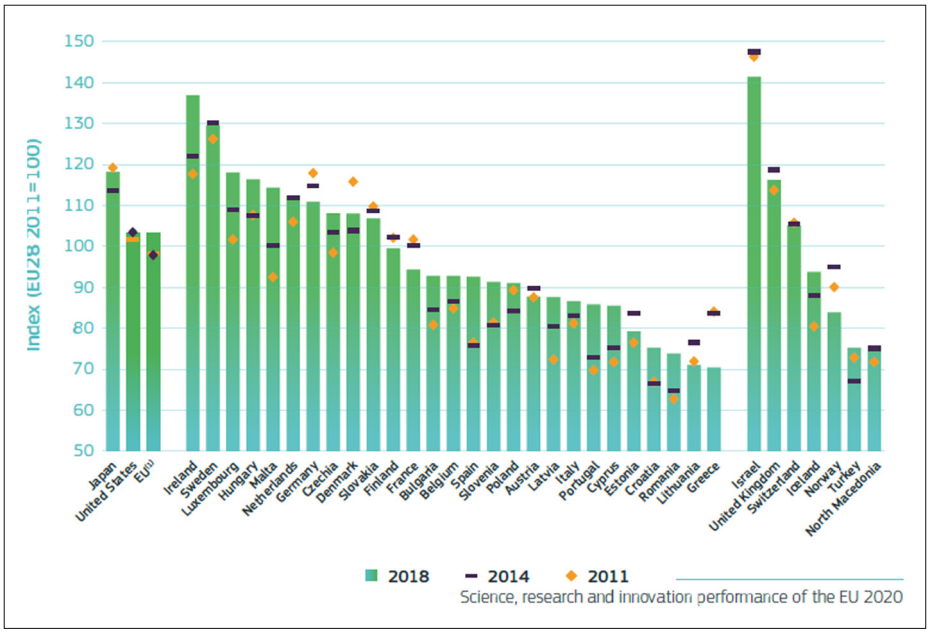

Figure 12: Innovation output indicator (EU2011=100), 2011, 2014 and 2018 (Source: DG Research and Innovation)

markets like the United States or China. The US market is very competitive and sophisticated, and Asian markets are even more challenging. Even growing within Europe has its challenges, because Europe is not a single entity; it is composed of a plurality of markets, languages, laws, cultures and so on. Therefore, it is difficult for a company to address the whole of Europe without extra work to adapt to each country. As an example, voice assistants appear later in non-English speaking countries due to the additional effort required to adapt them to different languages. Neither US or Chinese companies face such challenges. That is one of the explanations why European VCs are more cautious; they doubt whether many companies have the potential to successfully enter markets outside Europe.

Employment in ICT manufacturing is very low in the US and in the EU. China, Japan and South Korea are the ICT factories of the world. The US and the EU are strong in services, and on a par with South Korea and Japan (Figure 16).

Figure 13: 2019 Global startup ecosystem ranking (Source: DG Research and Innovation)

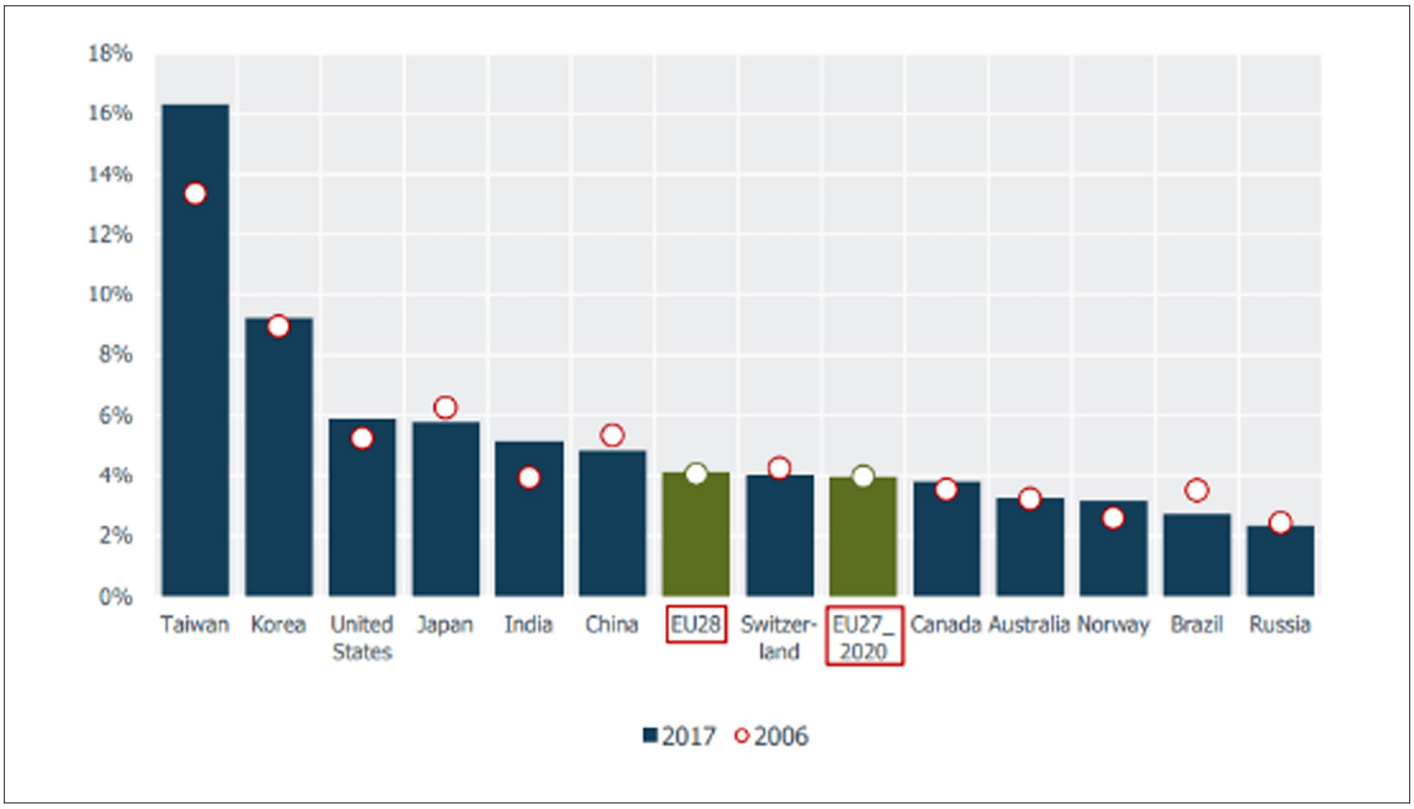

Figure 14: ICT sector value added share of GDP 2006-2017

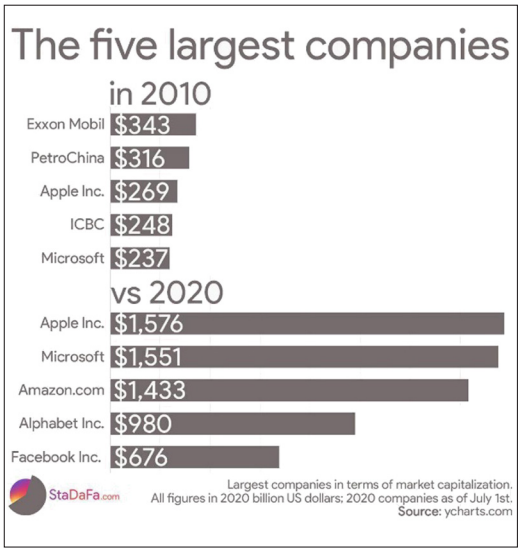

Figure 15: Largest global companies in 2010 and in 2020.

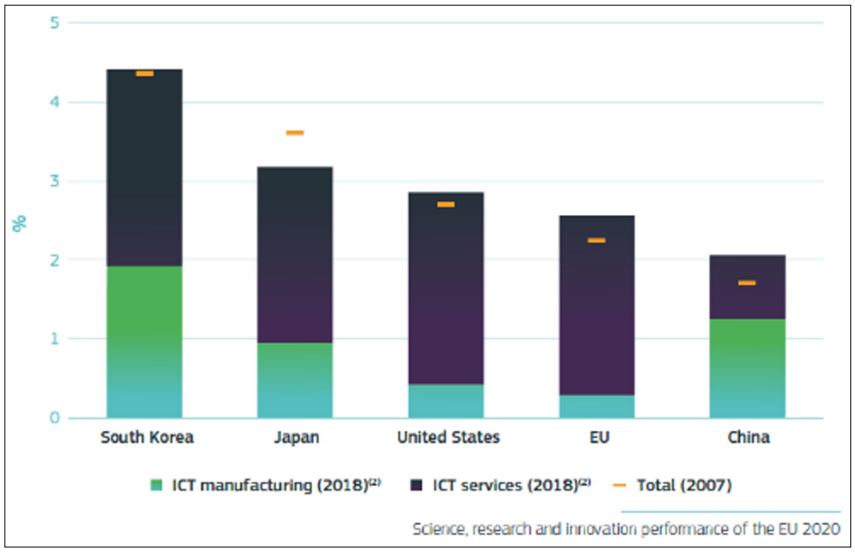

Figure 16: Employment in ICT as % of total employment broken down by manufacturing and services globally 2007-2018

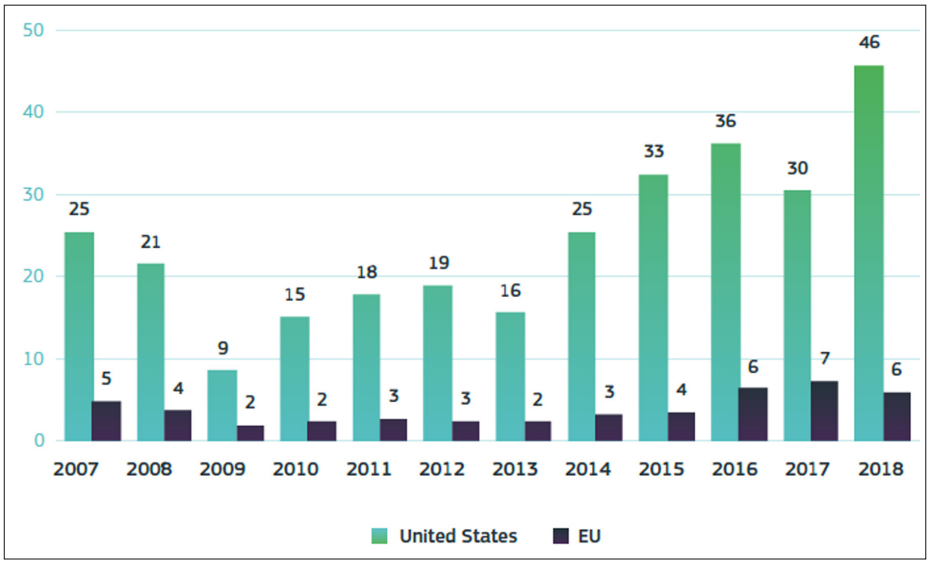

Figure 18: Venture capitalist funds raised (billion euro) in the EU and in the United States 2007-2018 (Source: DG Research and Innovation)

Figure 19: Venture capital average fund size (EUR million) in the EU and in the USA, 2007-2018 (Source: DG Research and Innovation)

The fact that Europe lacks major ICT companies has far-reaching consequences: it also means that venture capitalists are less eager to invest in European start-ups and scale-ups because there are fewer companies that might be able to acquire them. Companies that do grow significantly are often acquired by non-European companies: Nokia was acquired by Microsoft, Movidius by Intel, ARM by Softbank and more recently by NVIDIA, for example. Fortunately, there are also counterexamples like Sysgo, which was acquired by Thales.

Non-European business leaders like Elon Musk, Tim Cook, the Google founders and Masayoshi Son seem to have a clearer vision of the future than their European counterparts, which they promote actively in the media. Very few people know the CEO of major European computing companies like Infineon, Ericson and STMicroelectronics, who lack the "rock star status" associated with their international counterparts.

Lack of VC culture

More generally, Europe lacks a VC culture and, in this metric, the gap between the United States and Europe could not be bigger (Figures 18,19). This observation, in combination with the large number of young start-up companies, is problematic. It means that they have to fight hard to get the funding to become a scale-up company.

Lack of advanced foundries

There used to be foundries in Europe, but they were acquired by non-European companies and disappeared (Figure 20). The fact that Europe depends on foreign foundries means that it has to import most of its semiconductors. The leading foundries are not located in low-wage countries, meaning that they did not leave Europe due to labour costs. Given the fact that Europe is a world leader in the development of the technology used in foundries (CEA, imec, Fraunhofer, ASML), it is surprising that no large foundries are left in Europe and that Global Foundries some years ago decided to stop the development of 7nm technology and instead make its 14/12 nm FinFET platform more relevant to its customers. One explanation is that European countries did not aggressively invest in new foundries (as was the case in South Korea and in Taiwan), and that European VCs are not interested in foundries (while they are in the United States). Another is that the European customers of the foundries like STM, NXP and Infineon are making products that do not require advanced processes because their market is microcontrollers instead of microprocessors, analog devices versus memories.

Lack of ICT workers

Europe lacks hundreds of thousands of ICT workers. Most European countries are witnessing positive growth in the number of graduates overall, but the number of graduates does not yet match demand (Figure 21). It would seem that Europe is not succeeding in convincing large enough numbers of high school students to start a career in the ICT sector. This is unfortunate because the competitiveness of this sector in Europe will depend on the size of its workforce in order to innovate in big data analytics, artificial intelligence, robotics and so on.

Importing well-trained foreign workers to Europe en masse to help mitigate the shortage is not an effective solution. First of all, Europe needs more than one million ICT workers in the next decade. Secondly, most countries try hard to keep their local talent. Finally, Europe has become less inviting to immigrants during the last decade. To complicate things further, foreign ICT workers will be attracted by well-paid jobs in the major innovation hubs, and it will be more difficult to convince them to accept a job in smaller cities, or in poorer countries. The only long-term and sustainable solution is to invest heavily in the technical education of local people.

Fragmentation of funding

The public funding system in Europe is highly fragmented. There are national funds, regional funds and European funds. There are funding instruments for applied research, for innovation, and for fundamental research. There are individual grants and collaborative research grants. A particular research proposal could fit multiple funding instruments and calls. Sometimes a research proposal can only be funded if different agencies agree to each fund a part of the proposal. On top of this, the success rate for research proposals is sometimes lower than 10%.

Within a funding agency, different committees deal with particular topics, which makes multidisciplinary project proposals very hard to get funded because committees tend to give priority to the proposals that belong to the core of a domain, leading to *lower acceptance rates for interdisciplinary projects*. It is therefore very hard for technologies that are common to several application domains, such as research in computing hardware and software, to be funded for their own intrinsic development. Instead, they must piggy-back on more domain-specific

1Q20 Top 10 Semiconductor Sales Leaders ($M, Including Foundries)

1Q20 Rank	1Q19 Rank	Company	Headquarters	1Q19 Total IC	1Q19 Total O-S-D	1Q19 Total Semi	1Q20 Total IC	1Q20 Total O-S-D	1Q20 Total Semi	1Q20/1Q19 % Change
1	1	Intel	U.S.	15,799	0	15,799	19,508	0	19,508	23%
2	2	Samsung	South Korea	11,992	875	12,867	13,939	858	14,797	15%
3	3	TSMC (1)	Taiwan	7,096	0	7,096	10,319	0	10,319	45%
4	4	SK Hynix	South Korea	5,903	120	6,023	5,829	210	6,039	0%
5	5	Micron	U.S.	5,465	0	5,465	4,795	0	4,795	-12%
6	6	Broadcom Inc. (2)	U.S.	3,764	419	4,183	3,700	410	4,110	-2%
7	7	Qualcomm (2)	U.S.	3,753	0	3,753	4,050	0	4,050	8%
8	8	TI	U.S.	3,199	208	3,407	2,974	190	3,164	-7%
9	11	Nvidia (2)	U.S.	2,215	0	2,215	3,035	0	3,035	37%
10	15	HiSilicon (2)	China	1,735	0	1,735	2,670	0	2,670	54%
—	—	Top-10 Total		60,921	1,622	62,543	70,819	1,668	72,487	16%

(1) Foundry (2) Fabless
Source: Company reports, IC Insights' *Strategic Reviews* database

Figure 20: Top 10 semiconductors sales leaders (Source: IC Insights)

Figure 21: Graduated in the field of ICT per thousand population aged 25-34, 2017 and compound annual growth, 2010-17 (Source: DG Research and Innovation)

project calls. The organizational structure of the funding agencies thus ends up constraining the research work that can be proposed in one single project. The design of a novel, secure, cloud-based IoT solution will cut across the topics of at least three units of DG CONNECT. The fact that European Regional Development Fund has also started to be used to fund research only adds to the complexity.

Finally, there are the European state-aid rules that significantly add to the complexity.

Opportunities

Fortunately, there are also opportunities.

	Opportunities	Threats
Science and Technology	• The end of Moore's law	• Economic stagnation • Brain drain
Industry and Market	• Embedded systems, IoT, CPS, edge intelligence	• Saturating markets • Computing initiatives in countries such as China, Russia and Japan
Policy and Government	• Solutions for societal challenges	• Political instability

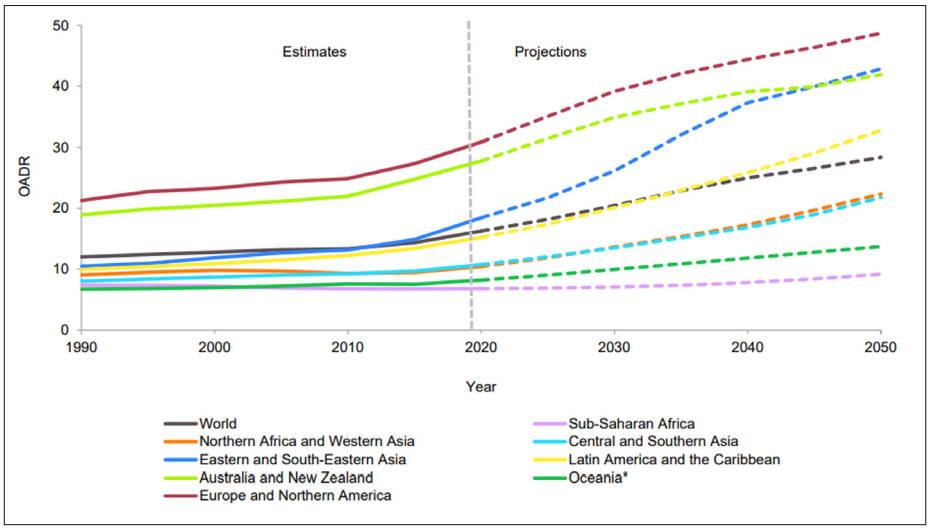

Figure 22: Ratio of people aged 65+ per 100 people of working age (old age dependency ratio) (Source: United Nations (2019))

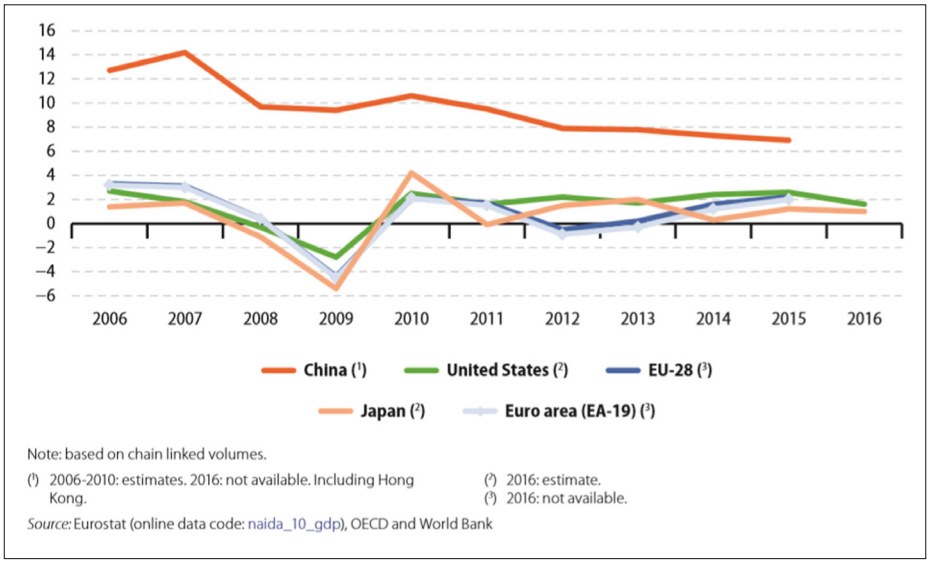

Figure 23: Real GDP growth 2006-2016 (% change compares with previous years) (Source: Eurostat)

The end of Moore's law

The increase of the sequential performance of a processor at the pace of Moore's law already ended a decade ago (end of Dennard's scaling); parallelism kicked in to keep performance increasing in lockstep with the number of transistors and cores, and now accelerators are the preferred technique to further improve performance, but the parallelism and the heterogeneity add a lot more complexity for software developers.

The design of accelerators marks a new era of architectural research to devise clever solutions to improve performance per Watt. There is, however, room (and also a need) for more disruptive solutions, possibly replacing the (rather inefficient) von Neumann architecture with other computing paradigms, but only if it is done with a high level of efficiency and in a short period of time. Progress in artificial intelligence could help in the efficient design of new systems.

Designing a new accelerator or launching a new technology is however a daunting task as the proposed solution has to be better than current solutions, and also needs to have a roadmap in order to keep the lead.

Embedded systems, IoT, cyber-physical systems (CPS), edge intelligence

The number one market opportunity in computing systems is the strongly growing market of embedded systems (including the IoT, CPS, edge intelligence and the digitization of European industry). Europe has the second largest economy in the world, it has a number of world-class players producing the key enabling technology for advanced embedded systems, and it has strong transportation and health industries. Furthermore, there are no non-European dominant companies like Google, Apple, Facebook, Amazon or Microsoft (GAFAM) in this space yet. The stars of the CPS era will probably not be the same as those of the internet era (which are different from those of the mainframe era). Could the company dominating computing in 2030 be European? The only way to win this race is to create as many innovative start-ups as possible, support them to scale up, and hope that they will become world leaders.

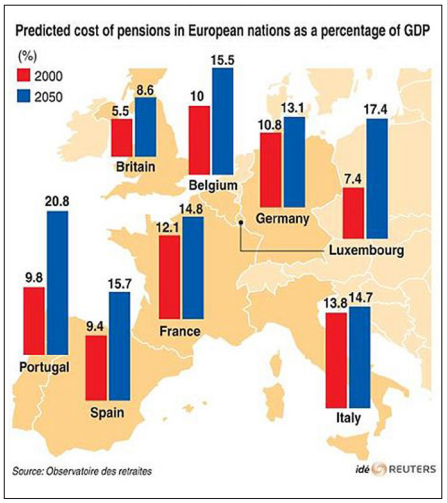

Figure 24: The cost of pensions in Europe [5]

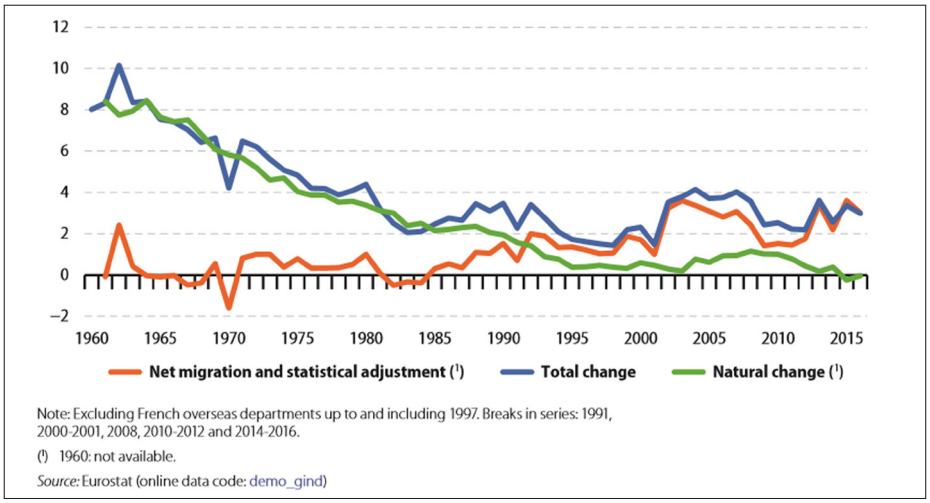

Figure 25: Population change by component (annual crude rates), EU-28, 1960-2016 (per 1.000 persons) (Source: Eurostat)

Solutions for societal challenges

Societal challenges form a huge opportunity for the European computing industry. Europe is the region with the highest number of people aged 60 or older [9]. The old age dependency ratio (OADR) is the number of 65+ people per 100 people of working age (24-64). That ratio will increase dramatically over the next 30 years (Figure 22). That means that Europe will have to search for solutions for the ageing population first. Since the rest of the world will face the same challenges in the future, Europe has an opportunity to develop and commercialize services and products for the silver economy first and sell them to the rest of the world.

The same reasoning holds for the environment. The European population (together with the US) has one of the largest ecological footprints in the world. Reducing the ecological footprint will become one of most important global challenges of the rest of the century. The European Green Deal will help European scientists and industry to find solutions for footprint reduction that can be used and applied across the world. This is a once in a lifetime opportunity.

Threats

Economic stagnation

Europe has been characterized by low economic growth in the past decade (Figure 23).

This situation has recently been aggravated by the economic impact of the COVID-19 pandemic. Around the time when the impact of the pandemic might become less severe, part of Europe risks experiencing the negative impact of Brexit. In the background, there is the increasing cost of supporting the ageing population. The cost of pensions will continue to grow until 2040 when "baby boomers" will have reached their life expectancy (Figure 24).

All the above puts stress on businesses, governments and people. Given the fact that European research is primarily funded by public money, this situation might lead to cuts in R&D budgets, especially for long-term curiosity-driven research.

Brain drain

There is a lot of public attention given to the topic of immigration in Europe. It is indeed the case that immigration has increased since the fall of the Berlin Wall in 1989 and is now a major source of population growth in Europe.

This graph, however, masks the fact that net immigration is the difference between immigration and emigration (Figure 25). Emigration usually takes place from economically weaker countries toward economically stronger countries: from the Middle East and North Africa to Europe, from Eastern and Southern Europe to North-Western Europe, but also from North-Western Europe to the United States and other rich countries in the world.

In computing, there seems to be a brain drain from Europe to the US. Top researchers and ambitious entrepreneurs are attracted by the merit-based American society and top salaries for high potential in both academia and industry. Large multinational ICT companies are attractive employers for young European talent eager to travel the world and make a fast career. If they do not want to move, US-based companies acquire European companies in order to have access to their talent or to open subsidiaries in Europe. This is a less visible form of brain drain. Particularly in machine learning, there has been a very strong pull on the top talent in Europe by companies like Facebook and Google.

Europe should create large and well-funded competence centres to retain European talent, and to attract excellent workers from abroad. CERN is a good example of such a competence centre, attracting talent from all over the world. The proposals for pan-European centres in artificial intelligence [6] and cybersecurity [7] launched recently will hopefully help fulfil this need.

Saturating markets

The market for new desktop computers and laptops is shrinking, and the market for smartphones is shrinking too (after having cannibalized the markets of other devices like navigation systems, cameras,

Image: ID 168883350 ©Cineberg Ug | Dreamstime.com

music and video players). The reason is that we have reached human scale: most people in the western world already have all the devices they need, and the features of most devices have stabilized, eliminating the need to replace devices to get access to more features. The COVID-19 pandemic and the requirement to work and study from home might have created a short peak in the demand for devices needed to telework (mobile devices, headsets, webcams), but this is not a long-term trend. Sustainability requirements encourage people to use devices until their end-of-life or have them repaired if they are not yet end-of-life. This will further reduce the demand in the longer term. Fewer sales means fewer resources to spend on the development of new devices and new features.

Computing initiatives in countries such as China, Russia and Japan

A threat to the European computing industry is the rapid development of the computing industry in China, Russia and Japan. Many countries understand that computing is a key enabling technology of strategic importance, and are investing in their own research, products and companies. If Europe fails to do the same, it might eventually become dependent on technology that is designed, developed, produced and controlled outside Europe. The same holds for cybersecurity solutions.

The fastest growing country of the moment is China. There are several sectors where it has the ambition to become a world leader (artificial intelligence [11] and renewable energy being just two examples). This is evident from the quickly growing number of patent applications by Chinese companies.

The ambition of China to become the frontrunner in artificial intelligence was made very clear in 2017 in their Next Generation Artificial Intelligence Development Plan [8]. It states: "*… by 2030, China's AI theories, technologies, and applications should achieve world-leading levels, making China the world's primary AI innovation centre, achieving visible results in intelligent economy and intelligent society applications, and laying an important foundation for becoming a leading innovation-style nation and an economic power*". China created a five-year AI talent training program, and invested more than US$2 billion in a huge AI industrial park in the suburbs of Beijing. The presence of Baidu, Alibaba and Tencent (BAT) is an asset in developing advanced AI applications. The fact that the Trump administration has put restrictions on Chinese companies will not change this.

Political instability

Another threat is the political instability that Europe and the rest of the world are currently experiencing. Brexit, the inability to form stable governments in some countries, the COVID-19 pandemic and the refugee crisis are influencing business and consumer confidence. In some countries, there is a trend towards more authoritarian regimes that want to turn back some liberal civil rights.

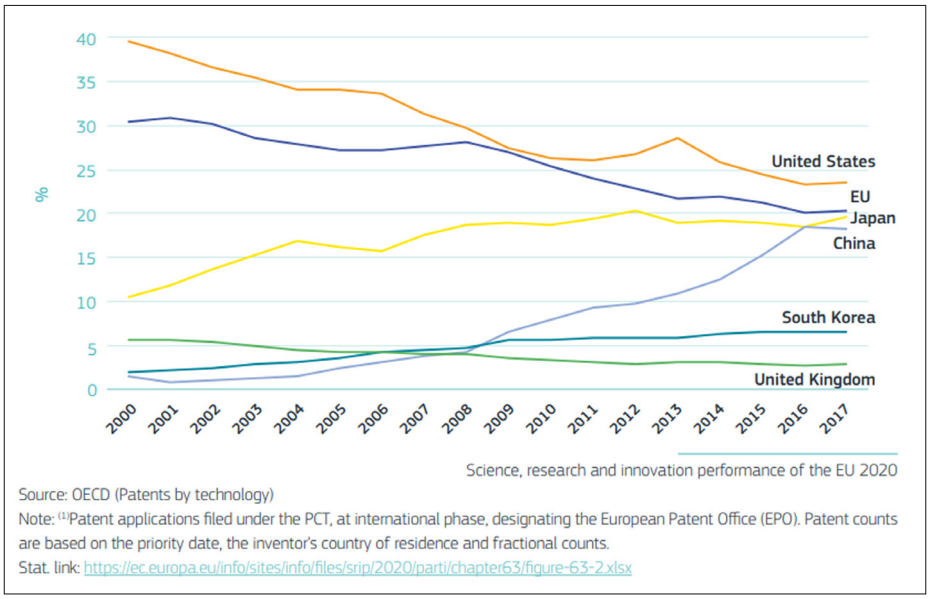

Figure 26: World share (%) of PCT patent applications 2000-2017 (Source: OECD (Patents by technology))

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